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MINERAL INFORMATION SERVICE

VOL. 4 June 1, 1951 No. 6

MINERAL INFORMATION SERVICE is a monthly news release concerning the mineral resources and industry of CALIFORNIA, designed to inform the public of the discoveries, operations, markets, statistics, and new publications. It is distributed without cost upon request.

ASBESTOS

Small quantities of asbestos, one of the strategic mineral materials in which the United States is deficient, have been produced intermittently in California for many years. Massive serpentine, the host rock for most asbestos deposits, is widely distributed in the state, largely in remote areas. In the future some of this California serpentine may yield asbestos from hitherto undiscovered deposits.

Of the fibrous minerals known as asbestos, chrysotile ($H_4Mg_3Si_2O_9$), a variety of serpentine, accounts for about 96% of the world's production. Chrysotile fibers of good quality are silky and flexible and have high tensile strength; if sufficiently long they may be spun into yarn or thread and woven into cloth. However, chrysotile is decomposed by acids whereas the amphibole varieties of asbestos are acid resistant.

The general term amphibole asbestos includes the fibrous forms of the minerals tremolite, actinolite, anthophyllite, amosite, and crocidolite. Crocidolite and amosite are commonly suitable for spinning, whereas tremolite and anthophyllite are most valued for their resistance to acids. California asbestos production has been almost entirely of the chrysotile and tremolite varieties; one mine has produced crocidolite.

Asbestos deposits of California, like the large deposits in Quebec, are contained mostly in massive serpentine formed by the alteration of magnesium-rich ultrabasic rocks. Chrysotile occurs in veins and veinlets in parallel or netlike arrangement within the serpentine mass. The value of a deposit is determined largely by the extent, width, and closeness of spacing of the veins. Most commonly the chrysotile fibers are perpendicular to the vein wall, that is, cross-fibered. However, in places the fibers are roughly parallel to the walls of the vein, or slip-fibered. The latter condition is more characteristic of tremolite asbestos than chrysotile. In some deposits of amphibole asbestos the entire rock is made up of fibers with no discernible regular orientation. These deposits are termed mass-fibered.

Potential chrysotile-bearing rocks, serpentinized peridotites, are widely distributed in all of the counties of the Coast Ranges, Klamath Mountains, and western foothills of the Sierra Nevada. Chrysotile deposits may also occur apart from massive serpentine. In Inyo County, for example, a recently discovered deposit is in the contact metamorphic zone in dolomite produced by a syenite intrusion. Metamorphic rocks of various types may contain amphibole asbestos. Tremolite asbestos occurrences are common in the state; however, they are usually limited to narrow veins and small pockets.

Asbestos has been produced and sold intermittently in small quantities in California since 1882. Although 15 counties have reported asbestos production and 17 additional counties have reported occurrences of asbestos since that date, no consistent production has been maintained anywhere in the State. Chrysotile has been produced from deposits in Calaveras, Napa, Nevada, San Benito, and Trinity Counties. Tremolite asbestos has been mined at many places in California, and a small quantity of long fiber crocidolite has been produced.

Asbestos is of two commercial classes: spinning and non-spinning fiber. The long, strong, flexible fibers are spun into yarn, which is woven into heat-resisting fabrics such as brake linings, tape, and cloth. Chrysotile is best adapted to this use, although the better grades of crocidolite, amosite, and very rarely tremolite can also be used. Some of the longer grades are used in magnesia block and pipe insulation consisting of 85 percent magnesia and 12 percent asbestos. Here, as well as in cements, plasters, and molded articles, the asbestos acts as a binder.

The shorter non-spinning grades are made into shingles, siding and paper. The use of asbestos-cement pipe for gas, sewer, and water mains is increasing as it is resistant to corrosion and shock-proof. Fiber waste and short length are used in making asbestos plaster, flooring, and as fillers in grease and paint. The best grades of tremolite and anthophyllite are acid-resistant and are used as filters in chemical laboratories. The low-iron variety of chrysotile found in Arizona is valuable in making electrical insulation tapes. Many new uses and adaptations for asbestos fibers are constantly being developed in the insulation and other industries. A typical example is the use of spray-coated insulation for metal, concrete, wood, and other surfaces.

Because large commercial deposits of asbestos, such as those in Quebec, usually cover extensive areas and the fiber content of the host rock averages only five to ten percent, open-cut large tonnage operations are almost always employed in the early stages of development. The rock is blasted, loaded by power shovels, and trucked to the recovery plant. Underground mining methods often succeed initial surface operations in the Canadian mines.

Milling consists of separating the fiber from the barren rock by repetitive crushing, screening, and air-suction separation. A typical mill flow sheet would include primary and secondary rock crushing to a 3-inch size, furnace drying to remove moisture, and third-stage crushing to free the fiber. The third stage crushing product, about $\frac{1}{2}$-inch size, flows to a longitudinal shaking screen. While proceeding along the screen the material is concentrated by gravity, producing a layer of light-weight fiber on top and a layer of heavier rock on the bottom. The lightweight fiber is removed through a suction hood installed at the end of the screen. The oversize is crushed to $\frac{1}{4}$-inch size and re-screened as outlined above. The undersize is fed to a fiberizer, a type of hammer mill which, by means of rotating hammers, strikes or throws the fragments against corrugated plates or jaws. Impact and attrition cause separation and fluff the fibers, which are then separated by another suction-screening operation. When free from rock, the fiber is passed to a two-level screen for size classification. The short lengths drop through both screens, the medium-length fiber is removed by air-suction from the end of the lower screen, and the long fiber is similarly removed at the end of the top screen.